IS 8252-21 (1986): Environmental test for aircraft equipment, Part 21 Explosion proofness [TED 14: Aircraft and Space Vehicles]

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(Reaffirmed 2005)

Indian Standard

ENVIRONMENTAL TESTS FOR AIRCRAFT EQUIPMENT

PART 21 EXPLOSION PROOFNESS

1. Scope — Specifies test requirements and procedures for aircraft equipment which may come into contact with flammable fluids and vapours. It also refers to normal and fault conditions that could occur in areas that are or may be subjected to flammable fluids and vapours during flight operations.

1.1 The flammable test fluids, vapours or gases referred to in this part simulate those normally used in conventional aircraft and which require oxygen for combustion (mono-fuels are not included).

1.2 This standard does not relate to potentially dangerous environments occurring as a result of leakage from goods carried on the aircraft as baggage or cargo.

1.3 In the order of testing, it is assumed that the article being tested has been subjected to the other environments of this standard (*see* **5**), as appropriate, prior to this test, namely, altitude tests, vibration tests, etc.

2. Definitions

2.1 *Explosion Proof* — Equipment is explosion proof when it has been determined that there is negligible risk that it will cause an explosion of a flammable gas or vapour within the declared environment.

2.2 *Intrinsically Safe* — Equipment is intrinsically safe when any spark or thermal effect produced normally (by making or breaking a circuit) or accidentally (by a short-circuit or earth fault) does not, under prescribed test conditions, cause ignition of a prescribed gas or vapour.

3. Categories of Equipment

3.1 *Category A Equipment* — is that which is designed:

a) to contain the ignition of an explosive mixture within the equipment without igniting an explosive atmosphere surrounding it and which meets the Category A tests (*see* **8.1**); and

b) so that during normal operation, or as a result of any fault, the temperature of any external surface will not rise to a level capable of causing ignition.

Hermetically sealed equipment meeting [*see* **3.1**(b)] shall be identified as Category A equipment.

3.2 *Category Y Equipment* — Equipment that is determined to be instrinsically safe shall be identified as Category Y.

3.3 *Category E Equipment* — Equipment meeting Procedure I of the Category E tests, but not intended for installation in Environment I, shall be identified as Category E1.

Equipment, including those hermetically sealed, meeting Procedure II of the Category E tests shall be identified as Category E2.

Such equipment shall be designed so that in normal operation the temperature of any external surface will not rise to a level capable of causing ignition.

3.4 *Category X Equipment* — Where equipment is intended for use on those parts of an aircraft where the probability of an explosive atmosphere existing is so low that it may be disregarded (Environment III) then the explosion test is not applicable and the specific equipment shall be identified as Category X.

4. Equipment Design and Installation

4.1 Equipment specifications shall detail any design constraints applicable to the particular category of equipment enclosure. Such design constraints shall include the following as appropriate:

a) Equipment which may come into contact with flammable fluids or vapours and which in normal operations may produce arcs, sparks or hot surfaces, shall be designed, having regard to its likely manner of installation, to be explosion proof.

[Ref : Doc : EDC 74 : 4 (4339)] Aircraft and Space Vehicles Sectional Committee, EDC 74; Environmental and Operating Conditions for Aircraft Equipment Subcommittee EDC 74 : 4

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b) Equipment which may come into contact with flammable fluids or vapours and which under fault conditions may produce arcs, electrical sparks, friction sparks or hot surfaces, shall be designed and installed to reduce to an acceptable minimum the overall risk of a fault occurring that will ignite the flammable vapours.

c) In designing the air supply system for forced air ventilated equipment, the possibility of contamination of the air by flammable vapours shall be taken into account. If the equipment and its ducting, including joints, are in an area which can be so contaminated, they shall be capable of meeting the conditions appropriate to the environment.

d) The specification for Category A equipment shall consider the design requirements of flange and hole dimensions or other equivalent means, such as flame traps for adequate safety from flame propagation.

5. Environment Definitions

5.1 *Environment I* — Environment I is an atmosphere in a space in which uncovered flammable fluids or vapours exist, or can exist either continuously or intermittently (for example, in fuel tanks or within fuel systems).

5.2 *Environment II* — Environment II is an atmosphere in which flammable mixtures can be expected to occur only as a result of a fault causing spillage or leakage, and where an explosive environment may occur.

5.3 *Environment III* — Environment III is an atmosphere where the probability of flammable mixtures arising from aircraft systems is sufficiently low to be disregarded, for example, within passenger cabins and well-ventilated areas not containing flammable fluids.

5.4 *Environment IV* — Environment IV is an atmosphere within a designated fire cone.

6. Explosion Proofness Test Requirement

6.1 The requirements for explosion proofness equipment and enclosures shall be as in Table 1.

TABLE 1 REQUIREMENTS FOR EXPLOSION PROOFNESS EQUIPMENT AND ENCLOSURES

Environments	Equipment Categories	Requirements and Tests, Clause Reference	Notes
I	*A*	8.1.1	1
	A (hermetically sealed)	8.1.2	
	Y	8.2.1	
II	*A*	8.1.1	2
	Y	8.2.1	
	E1 and *E2*	8.3.1	
	E2 (hermetically sealed)	8.3.2	
III	*X*	Not applicable	3
IV	*A*, *Y* or *E*	As for Environment II, but fault cases are not applicable	4

Note 1 — **6.2** applies.

Note 2 — **6.3** applies.

Note 3 — There is no requirement for equipment to be explosion proof under normal or fault conditions (*see* **6.4**).

Note 4 — **6.5** applies.

6.2 *Environment I* — The equipment shall meet the standards and test procedures of explosion-proof Category A or Category Y and it shall not be possible for any normal or fault condition to:

a) adversely affect the integrity of the enclosure, and

b) raise the temperature of any external surface to a level capable of causing ignition.

6.3 *Environment II* — The equipment shall meet the standards and test procedure of any one of the explosion-proof categories.

6.4 *Environment III* — There is no test requirement for equipment installed in this environment under normal or fault conditions (Category X).

6.5 *Environment IV* — These test requirements are the same as for Environment II except that fault conditions in the equipment need not be considered.

7. Test Procedures

7.1 *General* — To assure that equipment will fulfil the requirements of **6**, the test procedures specified below are required to determine compliance with the standard.

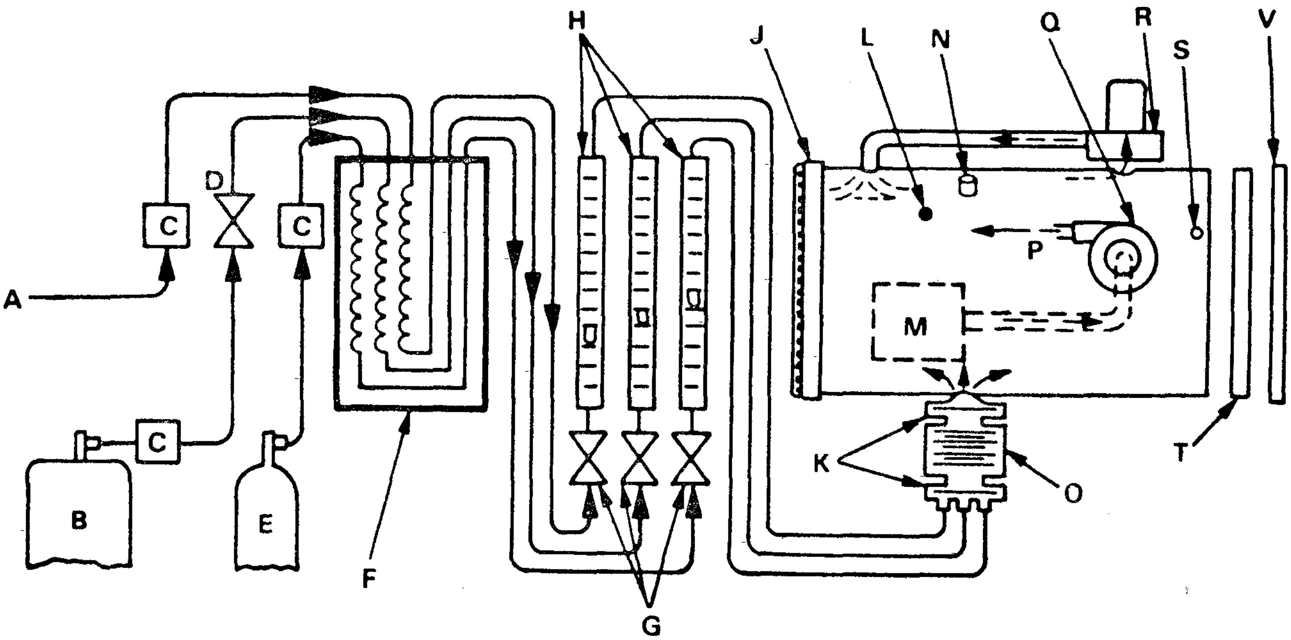
7.2 *Test Specimen* — The test sepcimens selected shall be representative of production equipment.

7.3 *Fuel* — Unless otherwise specified, the fuel used may be grade 100/130 octane gasoline, propane or normal hexane.

7.4 *Fuel Mixtures*

a) For gasoline, a stoichiometric mixture of 13 parts of air and one part of fuel by mass.

b) For propane, a 1·05 stoichiometric mixture of 3·85 to 4·25 percent by volume of propane and 96·15 to 95·75 percent by volume of air respectively (*see* Fig. 1).



A — Air
B — Propane Gas Container
C — Reducing Valves
D — Gas cut-off Valve Operated by Micro-Switches on Explosion Chamber
E — Oxygen Bottle
F — Heat Exchanger to Bring the Gases to Standard Temperature
G — Needle Valves
H — Flow Meters
J — Both Ends Covered by Diaphragms (E. G. Paper, Polyethylene) Held on by Rubber Bands
K — Diaphragm Check Valves
L — Cylindrical Explosion Chamber
M — Unit Under Test
N — Vent
O — Mixing Chamber
P — Waste to Atmosphere
Q — Extractor for Charging Unit Under Test
R — Stirring Blower
S — Micro-Switch (one at each end) Released when Rubber Band is Displaced by Explosion
T — Diaphragm
V — Rubber Band

FIG. 1 EXAMPLE OF APPARATUS FOR TESTING INEXPLOSIVE ATMOSPHERES

c) For hexane, a 1·8 stoichiometric fraction of normal hexane shall be calculated according to the following equation:

Volume of 95 percent normal hexane (ml) =

$$396 \times 10^{-6} \frac{[\text{ net chamber vol (litres) }]\,[\text{ chamber pressure (Pascals) }]}{[\text{ Chamber temp (K) }]\,[\text{ specific gravity of n-hexane }]}$$

The specific gravity of normal hexane can be determined from Fig. 2.

The equipment used to vapourize the fuel for use in the explosion proofness test shall be so designed that a small quantity of air and fuel vapour will be heated together to a temperature such that the fuel vapour will not condense as it is drawn from the vaporizer into the chamber.

When the test facility is designed for fuel vaporization inside the explosion chamber, the fuel may be introduced at the ambient temperature of the test site.

As an illustration of the procedure for calculating the mass of 100/130 octane gasoline required to produce the desired 13 to 1 air vapour ratio, the following sample problem is presented:

Required information:

Chamber air temperature during test	:	27·2°C
Fuel temperature	:	24°C
Relative density of fuel at 16·1°C	:	0·704
Test altitude (equivalent pressure, *P* : 95 kPa)	:	1 524 m
Air-vapour ratio (desired)	:	13 to 1

Step 1 — Employing the following equation, calculate the apparent air-vapour ratio (AAV) :

$$AAV = \frac{AV\text{ (desired)}}{1{\cdot}04\left[\dfrac{P}{101{\cdot}32}\right] - 0{\cdot}04}$$

$$= \frac{13}{1{\cdot}04\left[\dfrac{6{\cdot}75}{101{\cdot}32}\right] - 0{\cdot}04}$$

$$= 15{\cdot}62$$

where

AAV = apparent air-vapour ratio,

AV = desired air-vapour ratio, and

P = pressure equivalent of altitude, kPa.

At ground level up to 1 524 m altitude, with chamber air temperature above 16·1°C and at *AV* ratio of 5 or greater, air-vapour ratio = air-fuel ratio (*AF*) for 100/130 octane fuel. Since the conditions of the explosion test under consideration will always be well above these values, *AV* will equal *AF* in all cases.

Step 2 — Since $AV = AF$, use Fig. 3 to determine mass of air (*WA*) and divide by *AAV* to obtain uncorrected mass of fuel required (W_{fu}).

$$W_{fu} = \frac{WA}{15{\cdot}62} = \frac{3{\cdot}455}{15{\cdot}62} = 100 \text{ g, fuel mass (uncorrected)}$$

Note — Figure 3 pertains to a specific test chamber volume and shall not be used for all test facilities. It only illustrates the method employed. Each test chamber shall have its own chamber volume chart.

Step 3 — Knowing fuel temperatures and relative density at 16·1°C, use Fig. 4 to determine specific gravity at a given temperature.

Step 4 — Using Fig. 5, obtain correction factor *K* for the relative density determined during Step 3. Apply factor to obtain mass of fuel corrected (W_{fc}).

$$W_{fc} = KW_{fu} = 1{\cdot}01 \times 100 = 101 \text{ g fuel mass (corrected)}$$

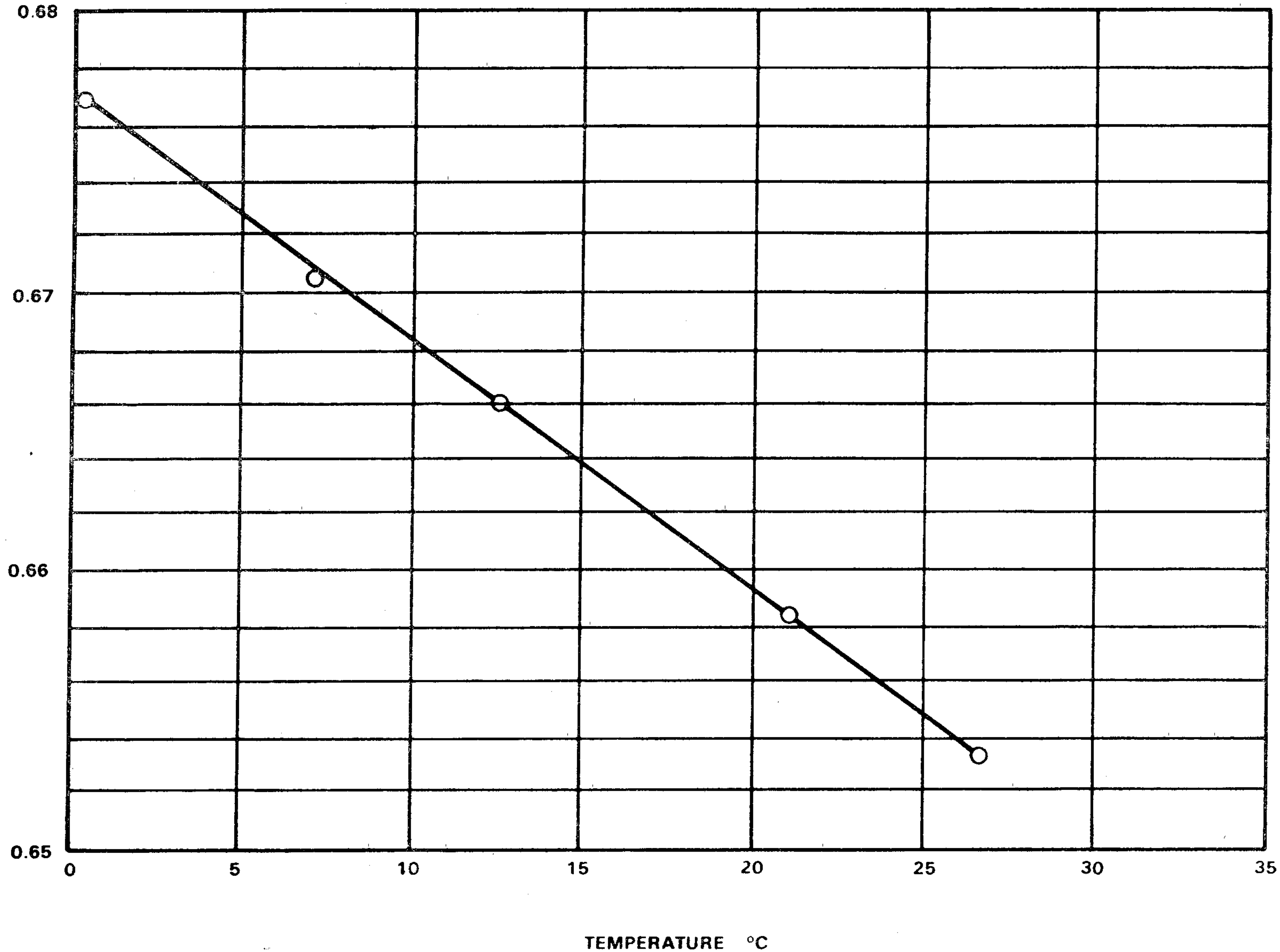


FIG. 2 SPECIFIC GRAVITY OF N-HEXANE

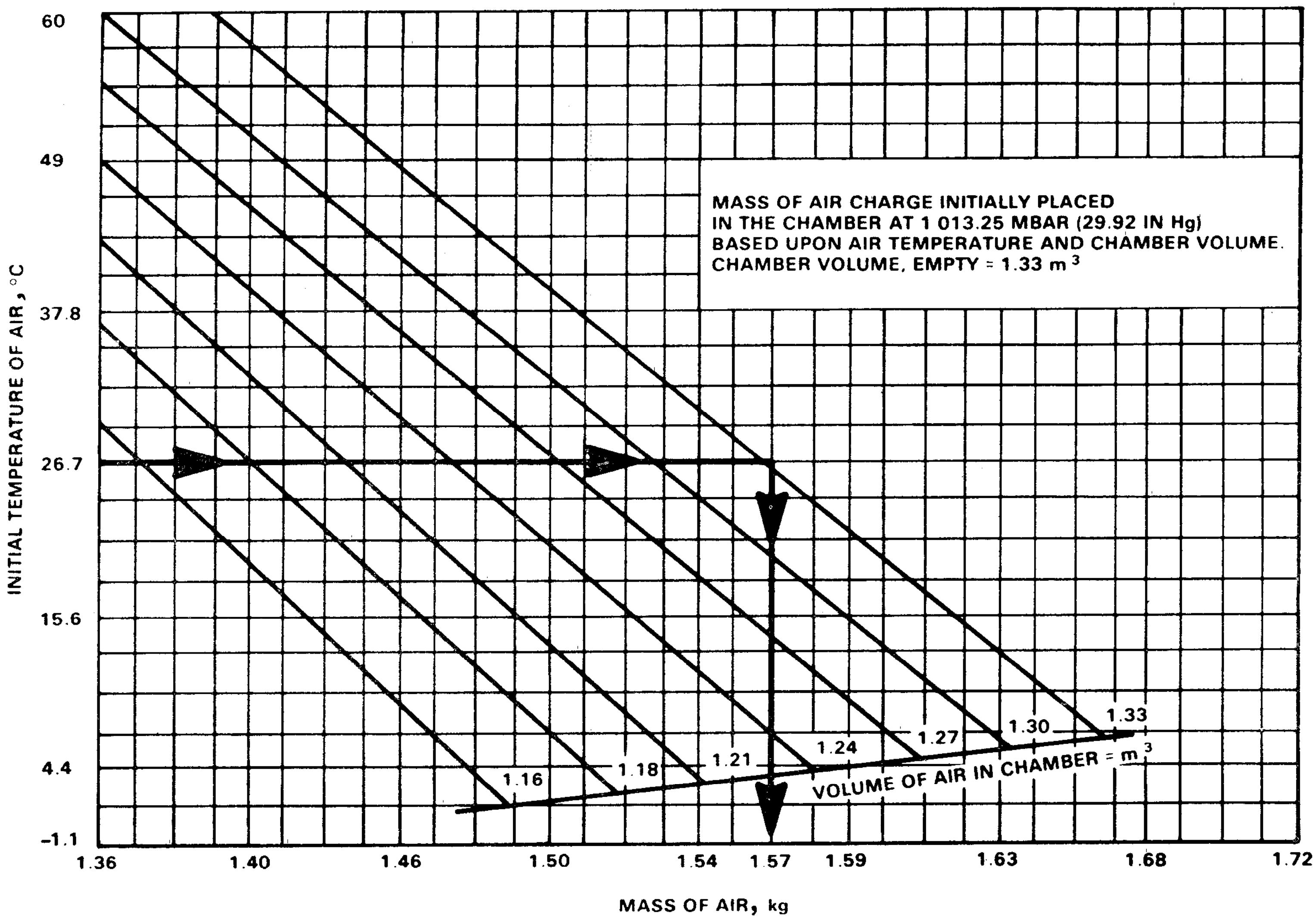


FIG. 3 MASS OF AIR CHARGE VS TEMPERATURE

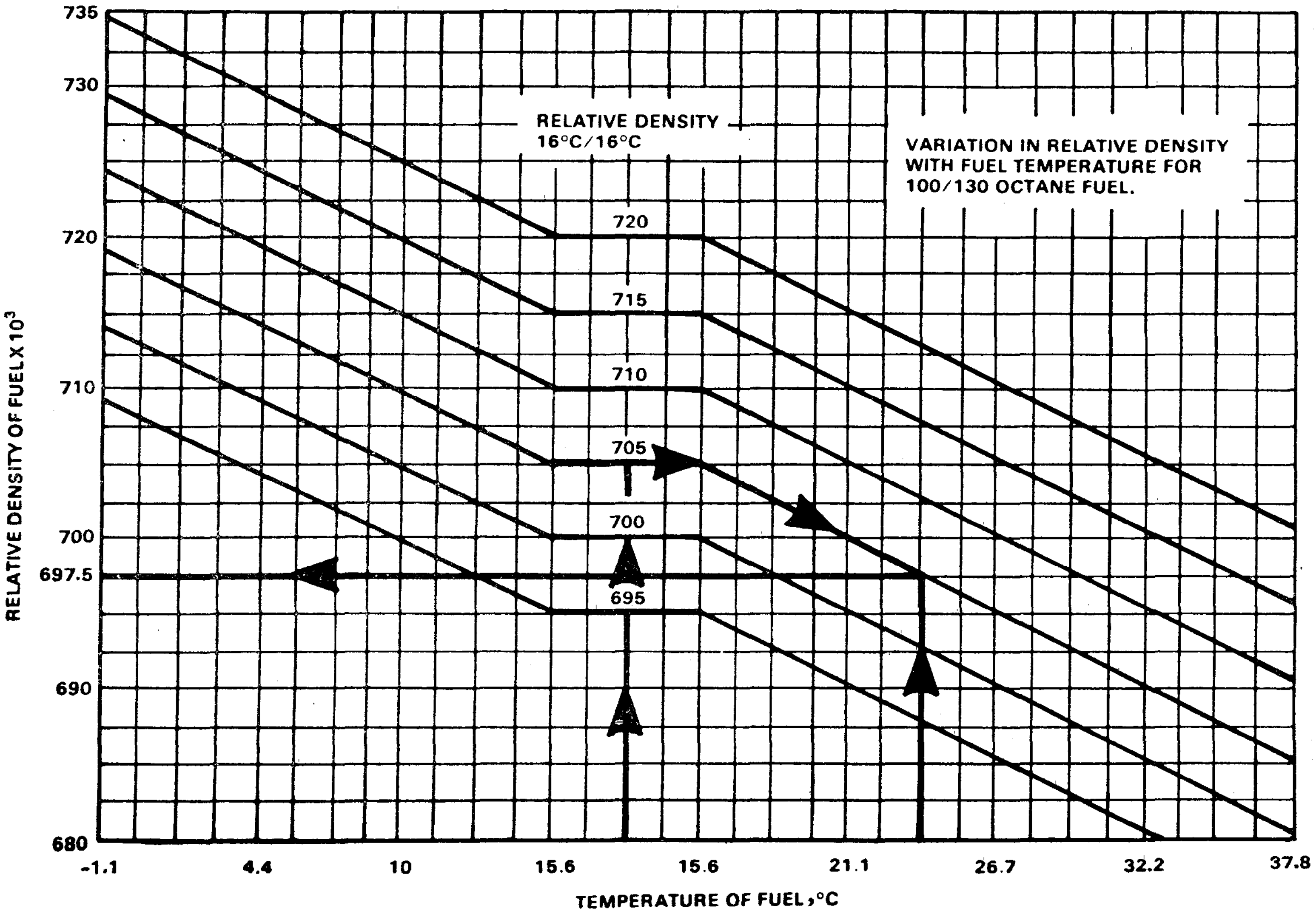


FIG. 4 RELATIVE DENSITY VS TEMPERATURE

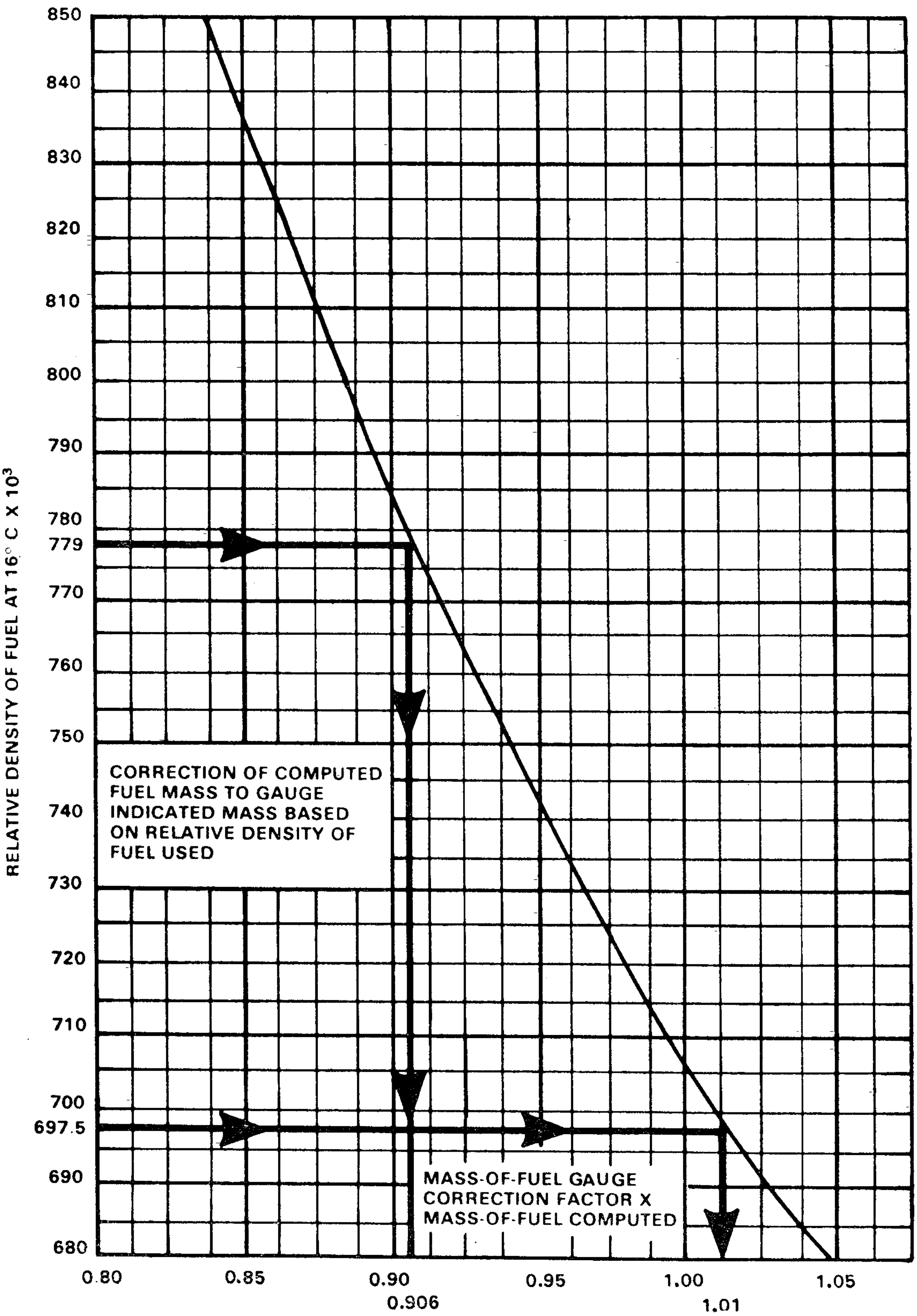


FIG. 5 FUEL MASS TO GAUGE INDICATED MASS CORRECTION FACTOR

8. Acceptance Test Procedure

8.1 *Category A Tests*

8.1.1 *Preparation of test*

a) *Preparation of Test Case or Enclosure* — When necessary, the test case or enclosure shall be prepared for explosion-proof testing by drilling and tapping openings in the case or enclosure for inlet and outlet hose connections to the fuel-vapour air mixture circulation system and for mounting a spark gap device. The case volume shall not be altered by more than ± 5 percent by any modification to facilitate the introduction of explosive vapour.

b) *Hose Installation* — When inserting a hose from a blower, adequate precaution shall be taken to prevent ignition of the ambient mixture by backfire or the release or pressure through the supply hose.

c) *Spark Gap Device* — A spark gap device for igniting the explosive mixture within the case or enclosure shall be provided. The case or enclosure may be drilled and tapped for the spark gap device or the spark gap device may be mounted internally.

d) *Case Installation* — The case or encloure with either the test item or a model of the test end of the same volume and configuration in position within the case or enclosure shall be connected and oriented in the explosion chamber mechanically and electrically, as recommended by the manufacturer for normal service installation. This shall include any cooling provisions as necessary to perform the tests described in **8.1.2**.

8.1.2 *Performance of test* — The test shall be performed three times as follows:

Step 1 — The chamber shall be sealed and the internal pressure maintained within the ambient pressures identified to simulate an altitude between ground level and 1 500 m. The ambient chamber temperature shall be at least 25°C. An explosive mixture within the chamber shall be obtained by using the mixture defined in **7.3** and **7.4**.

Step 2 — The internal case ignition source shall be energized in order to cause an explosion within the case. The occurrence of an explosion within the case may be detected by use of a thermocouple inserted in the case and connnected to a sensitive galvanometer outside the test chamber. If ignition of the mixture does not occur immediately, the test shall be considered void and shall be repeated with a new explosive charge.

Step 3 — At least five internal case explosions shall be performed. If the case tested is small (not in excess of 1/150 of the test chamber volume) and if the reaction within the case upon ignition is of an explosive nature without continued burning of the mixture as it circulates into the case, more than one internal case explosion, but not more than five, may be produced without recharging the entire chamber. Ample time shall be allowed between internal case explosions for replacement of burnt gases with fresh explosive mixture within the case. If the internal case explosions produced did not cause a main chamber explosion, the explosiveness of the fuel-air mixture in the main chamber shall be verified. If the air-vapour mixture in the main chamber is found not to be explosive, the test shall be considered void and the entire procedure repeated.

8.1.3 *Failure criteria* — If the internal case explosion causes a main chamber explosion, the test item shall have failed the test and no further tests need be conducted.

8.2 *Category Y Tests*

8.2.1 If required, test procedures shall be specified in the individual equipment specification.

8.3 *Category E Test* (*E1 and E2*)

8.3.1 *Procedure I* (*Category E1*) — Category E1 tests determine the explosion producing characteristics of equipment not hermetically sealed and not contained in cases designed to prevent flame and explosion propagation.

8.3.1.1 *Preparation for test*

a) The test item shall be connected and oriented mechanically and electrically as recommended by the manufacturer for normal service installation. This shall include any cooling provisions, as necessary to perform the tests described herein, and in such a manner so that normal electrical operation is possible and mechanical controls may be operated

through the pressure seals from outside the chamber. External covers of the test item shall be removed or loosened to facilitate the penetration of the explosive mixture. Large test items may be tested (one or more units) at a time by extending electrical connections through the cable port to the balance of the associated epuipment located externally.

b) The test item shall be operated to determine that it is functioning properly.

c) Mechanical loads on drive assemblies and servomechanical and electrical loads on switches and relays may be simulated if proper precaution is given to duplicating the normal load in respect to torque, voltage, current, inductive reactance, etc. In all instances, it is preferable to operate the test item as it normally functions in the installed environment.

8.3.1.2 *Performance of test*

The test shall be conducted between the ambient pressures identified to simulate at maximum test altitude of 12 000 m above mean sea level.

Step 1 — The test chamber shall be sealed and the ambient temperature within shall be raised to 71°C, or to the maximum temperature at which the test item is designed to operate if lower than 71°C. The temperature of the test chamber and the chamber walls shall be permitted to rise to within 11°C of the chamber ambient air, prior to the introduction of the explosive mixture, to prevent condensation of the explosive medium.

Step 2 — The required quantity of fuel (*see* **7.4**) shall be introduced into the chamber. 3 ± 1 min shall be allowed for introduction and vapourization of the fuel within the chamber.

Step 3 — At this time all electrical contacts of the test item shall be actuated. The operation of the test item shall be continuous throughout this period and all making and breaking electrical contacts shall be conducted as frequently as deemed practicable.

Step 4 — If no explosion has occurred as a result of the test item operation, the potential explosiveness of the air-vapour mixture shall be verified by igniting a sample of the mixture with a spark gap or glow plug. If the air-vapour mixture is not found to be explosive, the test shall be considered void and the entire procedure repeated.

8.3.1.3 *Failure criteria* — If the item causes an explosion, it shall have failed the test and further tests need not be conducted.

8.3.2 *Procedure II (For Category E2)* — Category E2 tests apply to hermetically sealed equipment or equipment containing hot spot surfaces (external or internal) and is non-spark porducing under normal operating conditions.

8.3.2.1 *Preparation for test* — The test item shall be placed in the test chamber in accordance with **8.3.1** and **8.3.1.1**. The suspected components or surface to be tested for thermal ignition shall be instrumented with thermocouples operating in a range of 65 to 260°C.

8.3.2.2 *Performance of test* — The test shall be conducted as follows:

Step 1 — The test chamber shall be sealed and the ambient temperature within shall be raised to 71°C, or to the maximum temperature at which the test item is designed to operate if lower than this temperature. The temperature of the test chamber and the chamber walls shall be permitted to rise to within 11°C of the chamber ambient air.

Step 2 — The equipment shall be turned on and operated in its normal mode until thermal stabilization of the equipment has been attained. The maximum temperatures attained at the suspected components or surfaces shall be recorded. If a temperature in excess of 204°C is attained, the test shall be terminated.

8.3.2.3 *Failure criteria* — In step 2 above, if the item does not exceed 204°C, the test item shall have passed the test and further tests need not be conducted.

If the item exceeds 204°C, the test item shall have failed the test.

EXPLANATORY NOTE

This standard is a part of a series of Indian standards specifying similar environmental tests for aircraft equipment subjected to demonstrate that it would function satisfactorily under normal aircraft operating conditions. The relevant equipment specifications would define the appropriate test severities and criteria for correct functioning.

This standard is based on the draft International Standard ISO/DIS 7137 'Aircraft — Environmental conditions and test procedures for air borne equipment', prepared by ISO/TC 20 the technical committee for aircraft and space vehicles.

Other Indian Standards in this series to be formulated are:

IS : 8252 Environmental tests for aircraft equipment:

- IS : 8252 (Part 1)-1975 General
- IS : 8252 (Part 2)-1980 Temperatures, pressure and humidity
- IS : 8252 (Part 3)-1978 Humidity (24 hours cycle)
- IS : 8252 (Part 4)-1980 Ice formation
- IS : 8252 (Part 6)-1976 Waterproofness
- IS : 8252 (Part 8)-1979 Change of temperatures
- IS : 8252 (Part 10)-1979 Saltmist
- IS : 8252 (Part 11)-1976 Differential pressure
- IS : 8252 (Part 14)-1982 Mechanical vibration
- IS : 8252 (Part 16)-1979 Shock
- IS : 8252 (Part 18)-1986 Magnetic influence

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